Do We Need a New Architecture for Simulating Power Systems? A Position Paper

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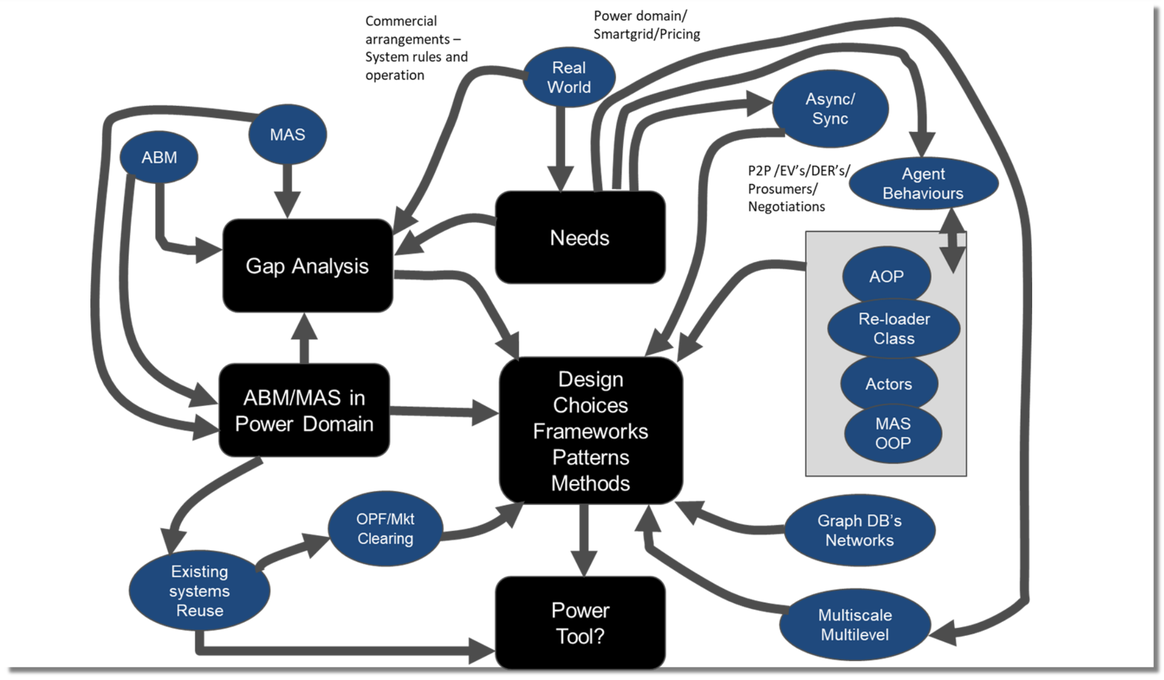
Research Introduction

- The delivery of electric power and organization and operation of electric power systems is a complex adaptive system (CAS)
- Will become ever more complex with an increased penetration of Distributed Energy Resources (DER), including electric vehicles and renewables
- Uncertainty in future evolution and structure of system
- New actors/agents, e.g. aggregators, will appear – how will they behave and evolve. Some will disappear – reinvent themselves
- Conventional Optimization is difficult
- Simulation provides a more holistic approach to understanding the evolving issues
- Both Synchronous and Asynchronous models
- We argue that although simulation frameworks exist they may be inadequate for simulating a more complex and evolving smart power grid infrastructure, and its operation, planning and regulation

Research Methodology



Existing Systems Review (ABM/MAS)

- Many surveys on ABM and MAS systems + dedicated webpages outlining what they can do in terms of ACL, openness, language etc.
- Few that we can find specifically on power based systems albeit researchers are using some of the systems above to build tools aimed at electric power systems, like AMES, EMCAS, Presage2
- ABM and MABMS (hybrid ABM/MAS like Presage2) simulators - are Synchronous
- MAS – Typically Asynchronous e.g. JADE
- Many papers conclude that for their application/research none of the systems really meet their needs – and so the justification for another system.
- Less researchers propose aggregation of systems or components (SAJas JRep,Wade)
- Electric Power Systems is a specific domain that need Asynchronous modelling and specialized models of network dynamics linked to ABM/MAS

Needs/Gap Analysis

Ranking Navajo Blanket Analysis

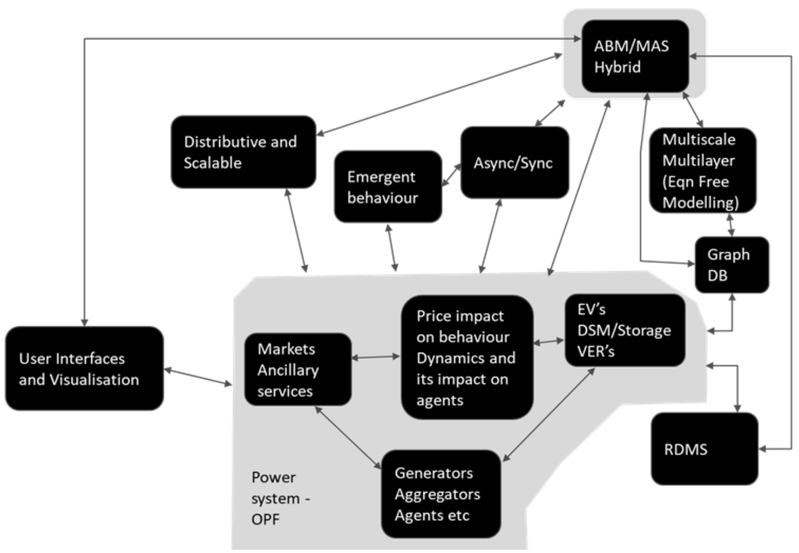
	Jade	Orbit/ Orleans	Pressage	Repast
BDI - agent behaviour				
FIPA Protocol				
Multiple networks				
Mobile agents				
Asynchronous				
GIS				
Visualisation/UI				
DSR Modelling				
EV Modelling				
Storage Battery etc				
Social capital				
Multi-Layer				
Multi-Scale				
Scale /Distributed				
Holonics/Norms				
Self Org Capability				
Clone agents				
Rule based Engine				
Maintained				

Best in Class

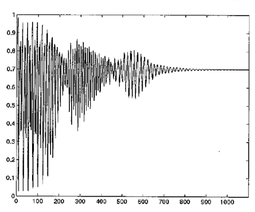
Gap

Repast HPC

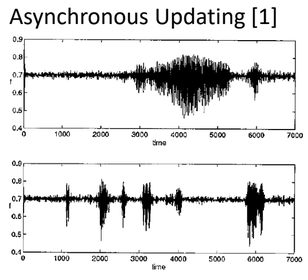
Proposed Structure



Synchronous Updating [1]

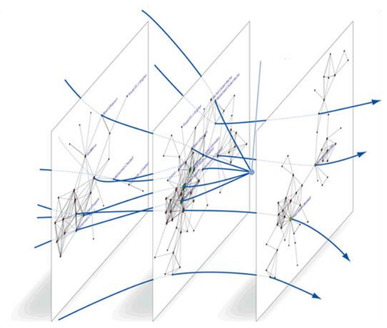


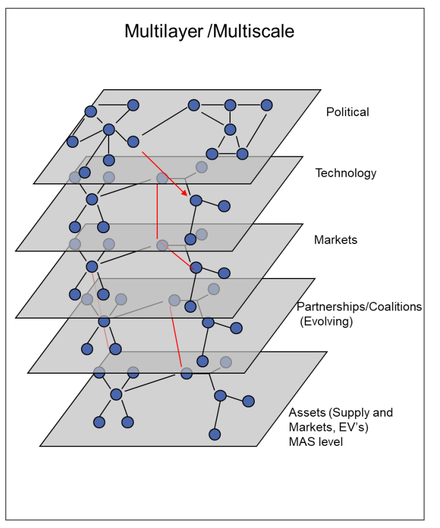
Asynchronous Updating [1]



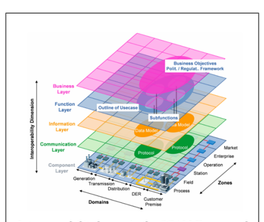
Networks and Agents Evolve

- Different priorities through time
- Network structure changes through time





- Modelling - naturally multi layered
- Each layer has interactions and interacts with other layers
- Layers evolve
- Layers interact at different time scales
- Some models do exist that use this sort of paradigm but not in power. Mainly social sciences



Interoperability layers in the SGAM Framework

Conclusions

- Extensive literature search on ABM/MAS systems, potential software architectures, component and reuse of Code carried out
- Experimentation with Java and python MAS/ABM systems (Orbit, Presage2, Repast EMLab ..)
- No one existing system that meets our need – useful elements in other systems approaches
- Power/smartgrid domain requires methods from both ABM/MAS and power specific domains
- Static designs not fit for our domain
- Reuse of code snippets and code segments design for future reuse

Future Work

- Building off extensive plumbing of OPF Code and reuse of code snippets – to build an ABM/MAS simulator for a power system
- Review and finalize design
- Build, Test and Validate (iterate)

References

[1] Youssefmir, M. & Huberman, B. A. 1997. Clustered volatility in multiagent dynamics. Journal of Economic Behavior & Organization, 32, 101-118.

EPSRC Engineering and Physical Sciences Research Council

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